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Comparative Study of PLC and Arduino in Automated Irrigation System

Mechelle Grace Zaragoza[1] and Haeng-Kon Kim[2*]

[1,2]*School of Information Technology,Catholic University of Daegu, Korea*
[1]*mechellezaragoza@gmail.com,*[2]*hangkon@cu.ac.kr*

Abstract

This paper is a comparative study on using PLC and Arduino in irrigation system by adopting the better ideas to what is more reliable in terms of usage, energy and cost. In which irrigation, electrical control technologies could improve irrigation efficiency, promoting water conservation and reducing the environmental impacts.

The study aims to change farmer's perspective on agricultural development by contributing to the spread of modern agriculture.Measuring soil moisture, humidity and sunlight are all important in agriculture to help farmers manage their crops efficiently. They were able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during dangerous plant growth stages. An embedded system for monitoring agriculture field offers a potential solution to support site-specific agriculture management that allows farmers to maximize their yield while saving the water and time. Agriculturist relies on bounty water to feed their hungry crops. It demands larger and more consistent amount of water than the unpredictable rain could offer to irrigate what nature by herself could never sustain.

Keywords*: Arduino, PLC, Automation, Irrigation System*

1. Introduction

In agriculture crop production, water balance is essential for high-quality agriculture production. Under-watered crops may suffer from nutrient deficiencies while over-watered plants may become more susceptible to disease and may lead to root death of suffocation. In addition, over-watered plants are not able to withstand dry roots during the dry season, especially in some tropical countries. [1]

The idea of knowing when and how much water crops may need are the two main important aspects of the watering process. To make is easier for the agriculturist to work things easily, the automatic plant watering system is created such as an irrigation system. But what is the better way to make this thing happen? [2]

Manual irrigation systems do not promote water conservation that may cause excessive amount or less amount of water in the soil, thus produces the problem in the growth of this plant. Automated irrigation systems are capable of determining and maintaining the right amount water in the soil and is being monitored. [3]

Automatic irrigation systems are convenient, especially for travelers. If installed and programmed properly, automatic irrigation systems can help you save money and water conservation. Dead lawn grass and plants need to be replaced, and that can be expensive, but the savings you get from automatic irrigation systems can go beyond that as watering is the most important cultural practice and one of the labor intensive tasks.

Automatic irrigation systems can be programmed to discharge more precise amounts of water in a targeted area, which promotes water conservation. [4]

*Corresponding Author

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New automated irrigation, electrical control technologies using either PLC or Arduino made could improve irrigation efficiency, promote water conservation and reduce the environmental impacts. [5]

Inexpensive, programmable microcontroller boards can make a sensor-based irrigation available for both agricultural and domestic applications. Such irrigation control systems can be built with only basic programming and wiring knowledge. This paper will discuss the difference between a PLC and Arduino and discuss any related project that might be useful in the future research and projects.

Our objectives were to use soil moisture sensors and microcontrollers to build an automated system to monitor and control substrate volumetric water content. [6]

To understand further this study, irrigation may be defined as the science of artificial application of water to the land or soil. This used for assisting the growth of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in areas limited to water and during the days where rainfall is inadequate. Automatic irrigation farming involves the use of a technology, preferably control system to control and monitor the irrigation. Agriculture is one of the fields where water is required to be in the right amount. Wastage of water is a major problem in agriculture, but there are many techniques to save or to control wastage of water from agriculture and we will discuss the following techniques and ideas in this paper. [7]

2. Background of the Study

In the history of irrigation developments, soils, climate, and water quality came together in more combinations at some locations than at others. Where seasonal rains provided leaching, where soils were leaky and well drained or irrigation water had promising combinations of electrolyte concentrations and specific actions, irrigation has continued to until today, even without proper management. In some areas, sanitation increased soil solidity, and elevated water tables have limited the period of irrigation schemes or reduced their productivity.

Agriculture in recent years, irrigated agriculture has greatly improved its ability to give humanity's essential needs. This remains a key priority in modern irrigated agricultural together with the continued improvement of production potential to meet the needs of a growing population. [8]

Historical studies also provide us with an understanding of the deeply rooted symbolic values of water, which play an essential role in how people today perceive a water shortage and the solutions proposed to alleviate it. [9]

Agriculture is by far has the largest average of water consumption. Irrigation of agricultural lands accounted for 70% of the water used around the globe. In several developing countries, irrigation represents up to 95% of all water uses and plays a major role in food production as well as food security. Future agricultural development strategies from most of these countries depend on the possibility to maintain, improve and expand irrigated agriculture. [10] Thus, this may be the main reason why we need to set proper water management studies.

3. The Role of Irrigation Water in Agricultural Systems

3.1. During Dry Periods, it Maintains the Soil Biological, Chemical Activity and Mineralization

In some dry areas, irrigation water artificially extends the time period in which soil biological activity and nutrient release are raised, creating more optimal growing conditions for cultivating crops.

3.2. Responsible for Soil Solution and Nutrient Uptake

Thus, water becomes an important medium into the plant's soil nutrient intake.

3.3. Provides Carbohydrate Building Block

6 CO2+ 6 H2O—>C6H12O6 + 6 O2: In the process of photosynthesis, as water molecules taken up by plants, these are broken down and rearranged by their constituent atoms to procedure new molecules which are carbohydrates and oxygen.

3.4. Promotes the Maintenance of Optimal Temperatures within the Plant

The loss of water through the process of evapotranspiration releases heat from the plant that regulates plant temperature.

3.5. Protecting the Crops from Frost Damage

Irrigation water is commonly used to lower the freezing temperature in during threats of damaging frost.

3.6. Eliminates Plant Stress

By eliminating stress on the plant improves it as quality of growing. Proper irrigation improves plants' resistance to pest and diseases. [11]

4. Arduino and PLC Explained

4.1. Arduino

Arduino is explained an open-source prototyping platform based on easy-to-use for both hardware and software. It provides an open-source and easy-to-use programming tool, for writing code and uploading it to your board. It is often referred to as the Arduino IDE or (Integrated Development Environment). The Arduino boards are able to read inputs - light, proximity or air quality on a sensor, or an SMS or Twitter message - and turn it into an output - activating a motor, turning on a light, publishing content online or trigger external events. You can tell your board what to do by writing code and uploading it to the microcontroller on it using the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has powered thousands of projects. Arduino has gathered around a community where beginners and experts from around the world share ideas, knowledge and their collective experience. There are thousands of makers, students, artists, designers, programmers, researchers, professionals and hobbyists worldwide who use Arduino for learning, prototyping, and finished professional work production.
http://www.arduino.org/learning/getting-started/what-is-arduino
It's a movement, not a microcontroller. Founded by Massimo Banzi and David Cuartielles in 2005
• Based on "Wiring Platform", which dates to 2003
• Open-source hardware platform
• Open source development environment
– Easy-to-learn the language and libraries (based on wiring language)
– Integrated development environment (based on Processing programming environment)
– Available for Windows / Mac / Linux [12]

4.2. PLC

A programmable logic controller is a specialized computer used to control machines and processes. It therefore shares common terms with typical PCs like central processing

unit, memory, software and communications. Unlike a personal computer though the A programmable logic controller is a specialized computer used to control machines and processes. It, therefore, shares common terms with typical PCs like central processing unit, memory, software, and communications. Unlike a personal computer through the PLC is designed to survive in a rugged industrial atmosphere and to be very flexible in how it interfaces with inputs and outputs to the real world.

The components that make a PLC work can be divided into three core areas.

The power supply and rack

The central processing unit (CPU)

The input/output (I/O) section

PLCs come in many shapes and sizes. They can be so small as to fit in your shirt pocket while more involved controls systems require large PLC racks. Smaller PLCs (a.k.a. "bricks") are typically designed with fixed I/O points. For our consideration, we'll look at the more modular rack based systems. It's called "modular" because the rack can accept many different types of I/O modules that simply slide into the rack and plug in. [13]

Programmable Logic Controllers (PLCs), also referred to as programmable controllers, are a classification in computers. It is a device that performs discrete or continuous control logic in a process plant or factory environments. PLCs are used in commercial and industrial applications. They have become popular since their inception in a wide variety of operations from the boiler control to robot control.

PLCs are programmed in two ways. One is to directly connect the PLC to a computer and the other is to make use of a programming panel. Logical commands are used to program the PLC in both scenarios. The panels used in programming a PLC differ greatly in their intricacies, ranging from simple keypads to handheld computers with a screen for graphics. [14]

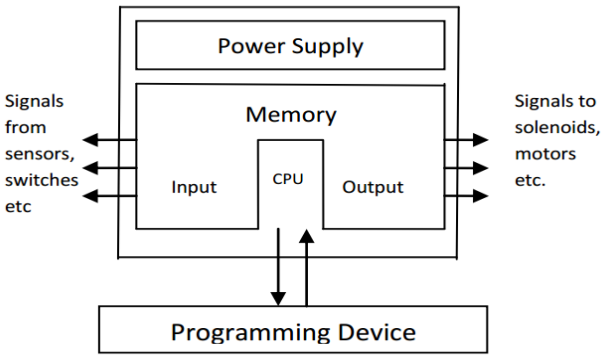

Figure 1. Programmable Logic Controllers Diagram

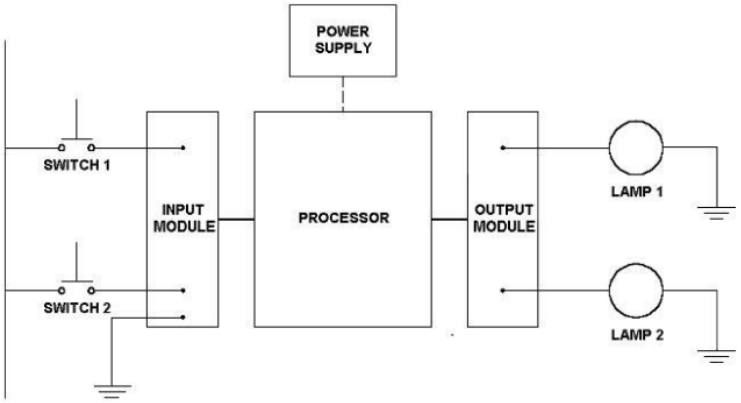

Figure 2. Programmable Logic Controllers Diagram

That kind of approach used by the PLC modules depends on the type of input device. For instance, some digital answers. Items from an on or off, which some corresponds to analog signals, and signaled to the others to answer. In this case, the analog signal representing the conditions of the processing machine and the current values or voltage range. The CPU evaluates the status of inputs, outputs and other variables that are stored in the program. The CPU sent signs to update the current output state. [15]

5. Arduino Projects

5.1. Smart Water Irrigation System

by: Siyu Chen, Nicolas Fatras and Haoran Su

Our system takes in real-time data on the water content of the plant as input argument, combines it with other parameters such as water cost, schedule and precipitation on the crop field, runs the designed linear optimization system periodically and outputs the most efficient amount of water the plants need, which is translated by a specific actuation time of the water pumps. The linear optimization system, which is essentially the brain of our system, is able to make decisions for the users when to distribute water into the crop fields and how much water should be delivered. Used Arduino Uno: Arduino is our microcontroller, which can receive the data collected by sensors and send signals to control the actuators. It's also connected to a computer, which can send data and receive data from the computer. [16]

5.2. Microcontroller-Based Irrigation System,

by: Kimani Paul Njoroge

The increasing world population has led to an exponential increase in food demand. This event has necessitated the need for more land to be cultivated. Due to change of weather patterns brought about by global warming, irrigation remains as the only reliable method of crop production. With more and more land now being under irrigation, there is a need for optimal use of water. [2] Over the last few years knowledge in electronics and computation has been used to solve present day challenges. In the forefront of the electronic revolution has been the microcontroller. The microcontroller has been used together with various sensors to measure and control physical quantities like temperature, humidity, heat, and light. By controlling these physical quantities using the microcontroller; automatic systems have been achieved. Irrigation systems in crop production can and has also been automated. This solves the challenge brought about by the unreliability of climate changes, thus need for water optimization. Automation of the

irrigation systems is one of the most convenient, efficient and effective method of water optimization. The systems help in saving water and thus more land can be brought under irrigation. Crops grown under controlled conditions tend to be healthier and thus give more yields. The controlled watering system results in a reduction of fertilizer use and thus fertilizer costs go down. The scope of this project entails the design and implementation of a micro controlled irrigation system, depending on the soil moisture content. Humidly/moisture sensor will be the input of the system and an electric water pump will be the output of the microcontroller. A system to monitor moisture levels in the soil was designed. The system was used to switch on/off the watering system/pump according to set soil moisture levels. The control unit the prototype was implemented using a microcontroller on Arduino platform while the sensing bit was implemented using SMS YL-69. Three LEDs and an LCD were used to implement the display of the three soil states *i.e.*, soggy soil, moist soil, and the dry soil states. To switch between the control and the irrigation systems a relay switching circuit was used. [17]

5.3. Wirelessly Controlled Irrigation System

by: Zain-Aldeen S. A. Rhman Ramzy S. Ali Basil H. Jasim

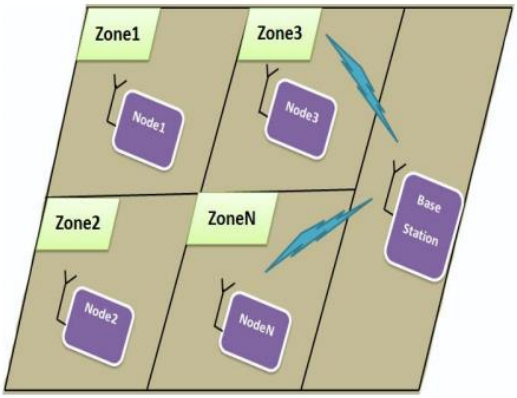

Figure 3. Wirelessly Controlled Irrigation System

This system consists of the main unit that represented by an Arduino Uno board which include an ATmega328 microcontroller, different sensors as moisture sensors, temperature sensors, humidity sensors, XBee modules and solenoid valve. Zigbee technology is used in this project for implementing wireless technology. This system has two modes, one manual mode; the other is a smart mode. The set points must be changed manually according to the specified season to satisfy the given conditions for the property irrigation, and the smart operation of the system will be according to these set points.
The proposed system was applied to anvil's plants and in the actual field for measuring required data from the agricultural field as soil moisture, surrounding humidity and air temperature.sing Arduino uno. [18]

5.4. Arduino based Automatic Plant Irrigation System with Message Alert

by: Saddam

Whenever we go out of town for a few days, we always used to worry about our plants as they need water on a regular basis. So here we are making Automatic Plant Irrigation System that uses Arduino, which automatically provides water to your plants and keep you updated by sending a message to your cell phone. In This Plant Watering System, Soil Moisture Sensor checks the moisture level in the soil and if the moisture level is low, then Arduino switches On a water pump to provide water to the plant. Water pump gets automatically off when the system finds enough moisture in the soil. Whenever system

switched On or off the pump, a message is sent to the user via GSM module, updating the status of the water pump and soil moisture. This system is very useful in Farms, gardens, home *etc.*, This system is completely automated and there is no need for any human intervention.

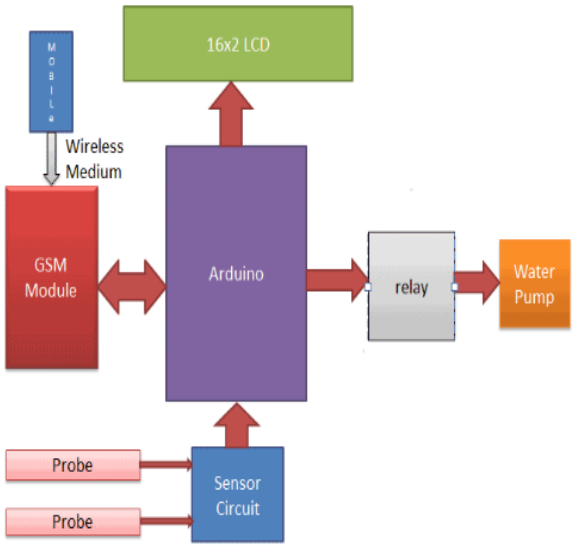

Figure 4. Automatic Plant Irrigation System with Message Alert Diagram

So with this Automatic Irrigation System, you don't need to worry about your plants when you are away from your home. It can be further enhanced to be operated and monitored over the internet. [19]

5.3. Cooperative Automatic Irrigation System using Arduino

by: Getie Dereje Derib

This paper presents an effective system of irrigation. The designed system basically has two inputs and two outputs. The inputs are moisture sensor and level sensor, whereas the outputs are pumping motor and a solenoid valve.

Project explains the following:

1. Crystal Oscillator
2. Soil moisture sensors
3. Liquid Crystal Display-
4. Motor Driver-
5. Relay:
6. Arduino Uno:[20]

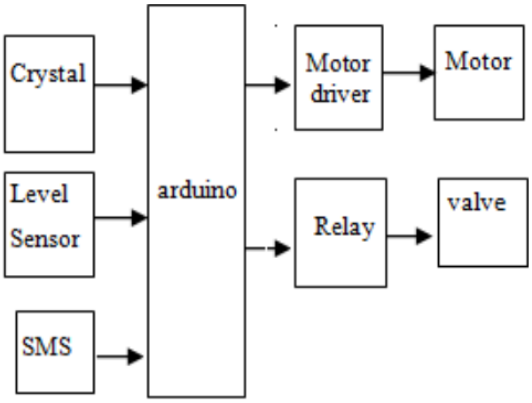

Figure 5. Block Diagram of the System

6. PLC Irrigation Projects

6.1. Development of Solar Powered Irrigation System

by: AI Abdelkerim, MMR Sami Eusuf, MJE Salami, A. Aibinu and M A Eusuf

Development of a solar powered irrigation system has been discussed in this paper. This system would be SCADA-based and quite useful in areas where there is plenty of sunshine, but insufficient water to carry out farming activities, such as rubber plantation, strawberry plantation, or any plantation, that requires frequent watering. The system is powered by solar system as a renewable energy which uses solar panel module to convert Sunlight into electricity. The development and implementation of an automated SCADA controlled system that uses PLC as a controller is significant to agricultural, oil and gas monitoring and control purpose purposes. In addition, the system is powered by an intelligent solar system in which solar panel targets the radiation from the Sun. Other than that, the solar system has reduced energy cost as well as pollution. The system is equipped with four input sensors; two soil moisture sensors, two level detection sensors. Soil moisture sensor measures the humidity of the soil, whereas the level detection sensors detect the level of water in the tank. The output sides consist of two solenoid valves, which are controlled respectively by two moisture sensors. [21]

6.2. PLC Control Systems for Irrigation Automation

This Prototype Irrigation system uses soil moisture probes to send a signal to a PLC controller at preset moisture levels. When the probe reaches a low set point, the PLC sends a signal to open the irrigation solenoid. After the irrigation has run long enough, and the probe reads the set high point, the PLC sends a signal to close the irrigation solenoid. A touch screen is used to monitor this system as well as make adjustments to the program on the fly.

This system is designed to reduce water usage. This has many benefits: reduced chemical runoff, reduced disease pressure due to dryer conditions, as well as a reduced amount of water used. This system also has the capability to support automated fertilizer injection with minimal modification. [22]

Figure 6. PLC Control Systems for Irrigation Automation Diagram

6.3. PLC Based Automatic Irrigation System

by: Shivam Poonia

Purpose and Scope. The main purpose of this project is to develop an irrigation system which works on sensors. By implementing this project, it can help to use water and energy efficiently, without excess wastage. New irrigation, electrical control technologies could improve irrigation efficiency, promoting water conservation and reducing the environmental impacts. [23]

6.4. Automatic Irrigation System using a Programmable Logic Controller

by: Mostefa M.Ghassoul

This paper presents a design of a programmable logic controller based system to control an automatic irrigation system . The system is composed of three modules: the solar panel producing energy stored in a battery, water storage and the irrigation system. The irrigation system composes of three samples simulating three different agriculture fields. The Humidity of each field is different from that of other fields according to the requirement of different plantation. It is controlled by two sensors, for minimum and maximum humidity. Each sample is irrigated by a separate valve. The valves are controlled by the PLC. If the maximum humidity is reached, the PLC turns off the concerned valve feeding the concerned sample. When all samples have reached their respective maximum humidity, the PLC turns off the main pump. The system has been designed, built and tested successfully. The project presented here is cost effective, robust and flexible, where one could change the design with ease due to the flexibility of the programmable logic controller. It is highly suitable for the Kingdom, where solar energy is in abundance and water is a commodity. [24]

6.5. Water Saving with a PLC Based Adaptive Irrigation System

by: S. SHAHIDIAN, R. P. SERRALHEIRO, J. L. TEIXEIRA, F. L. SANTOS, M. R. G. OLIVEIRA, J. L. COSTA, C. TOUREIRO, N. HAIE and R. M. MACHADO.

Irrigation is presenting the main user of the world´s fresh water. Most of it goes to irrigating small plots where it is not feasible to implement full-scale Evapotranspiration based irrigation controllers. The dramatic development of Programmable Logic

7. Comparison

Table 1. List of Arduino and PLCAdvantages and Disadvantages

Arduino		PLC	
Advantages	Disadvantages	Advantages	Disadvantages
Cheaper	Not very robust	More robust	More expensive
A lot of information are available	Works with 5V signals	More Reliable	More difficult to program
Accessible to anyone		Flexible	
		Possibility of expansion by slots	

Table 2. Arduino vs PLC

Arduino	PLC
Programmable in C++	Ladder Programming, Structured Text, Instruction List, and GRAFCET
Cheap, reliable PLC, and a Experience in open hardware codes	Comes with industry certifications and Has a number of safety characteristics
Available to all users	Suitable for industrial applications
Lots of information Shared between them Users and their software	A limited number of examples of Applications in software and internet [18]

Controllers, PLCs, and their rather affordable price has made it possible to use them as stand-alone irrigation controllers. In this paper a PLC is used to adapt the daily irrigation amount to actual ETc, using a Hargreaves-Samani type equation. Once the ETc is calculated, then the PLC manages the irrigation according to the specifications given by the farmer. First year results indicate an 8% saving in irrigation water. A rather inexpensive PLC was used to make hourly measurements of air temperature at a height of 1.5m. These temperatures were registered and used by the PLC to calculate daily Evapotranspiration from a cornfield. The program then used this information to apply the exact depth of water needed by the crops to ensure maximum production. The first year results were very satisfactory indicating an 8% water saving, along with some increase in crop yield, when compared to irrigate with a fixed water depth using a standard irrigation controller. [25]

8. Conclusion

In both useful programming agriculture projects, Arduino and PLC made its way to the development of projects around the world. However, Arduino has inspired creativity in digital electronics. The effect of its radical development of new ideas based solely on the voluntary contributions from users around the world. In terms of reliability, cost and availability, agriculturist must focus on the using Arduino but future studies may both combine PLC and Arduino to create a more suitable sensor based irrigation to supply water and what plants might demand.

Acknowledgments

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